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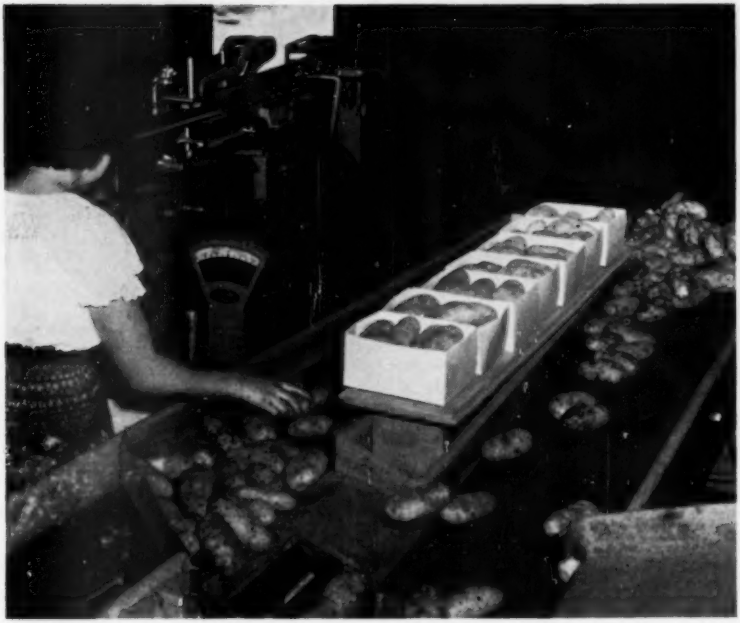

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EXTREME CASE OF SOIL TOXICITY TO POTATOES ON A FORMERLY PRODUCTIVE SOIL[1]

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(Accepted for publication February 25, 1951)

Very poor growth of potatoes was noted on a large field in central Connecticut in 1946. On a few spots in that field and on other fields of the farm, potatoes appeared quite normal. The owner stated that the potatoes had been grown on the unproductive field for thirteen consecutive years and had received annually a ton or more of 5-8-7 or 5-10-10 fertilizer, but very little if any, lime. It had produced very large yields in the late 1930's, but growth had been rather unsatisfactory for two or more years before 1946. Since 1946 other fields on the same farm and on other farms developed the same trouble. One sixteen acre field of Katahdin potatoes on this farm produced only an average of fifty-five bushels per acre in 1948. The soil toxicity condition was considerably less injurious to Green Mountains than to the Katahdin variety.

In order to determine the causes and cures of this poor growth of potatoes, greenhouse, laboratory, and field experiments were started in 1946 and the results are reported here.

[1] Contribution from Agronomy Section of Plant Science Department, Storrs Agricultural Experiment Station, Storrs, Conn.
[2] Agronomist, Agronomist, and Assistant Agronomist, respectively.

Description of Soil and Cultural Practices

The unproductive soil is classified as Hartford fine sandy loam, formed from glacial out-wash, red Triassic shale and sandstone. Coarse sand and gravel are found about two feet below the surface, making drainage excessive. Before 1930, tobacco had been grown on this area, but potatoes have been planted nearly every year since that time. For several of those years, no rye cover crop was planted in the fall after harvesting potatoes. Little or no lime had been applied. Highly acid forming complete fertilizer was used during the last few years.

The pH of the soil in early spring is about 5.0. Reactions of pH 4.4 to 4.6 have been found in samples taken in the potato row above the fertilizer bands during the growing season. The soil contained 2.7 per cent organic matter; clay, 10; and 45 per cent total sand. The exchangeable potassium was medium in amount whereas calcium and magnesium were relatively low, being 0.4, 1.4 and 0.2 m.e./100 grams respectively. The readily available nutrients and toxic elements by the Morgan method show the soil very high in aluminum and manganese, high in phosphorus and potassium, low in magnesium and iron, and very low in calcium. These analyses are very similar to those of many other potato soils and to soils from adjacent fields and farms where excellent crops of potatoes are produced.

Description of Abnormal Growth of Potatoes

The potato plants were very small, and spindly, with branches rising at acute angles. The leaves were small throughout the season, but the color of the foliage was similar to those of leaves from normal plants. The type of growth was similar to that of potatoes suffering from a severe deficiency of phosphorus. (Figures 1 and 3). The roots were short, stubby and had few branches. In severely affected areas of the field, it was found that very few of the roots grew long enough to reach the fertilizer bands placed two inches to the side of and on a level with or slightly below the lower plane of the seed piece. On one of the unproductive fields in 1948, black dots on the underside of leaves and on the stems were found. Black lesions were also found on the stems of potato plants in this field. These lesions were similar to those described as stem streak necrosis by Berger and Gerloff (2). However, these characteristics were noted in only one instance under field conditions and were not generally found on stunted plants in unproductive fields. Black streaks were not found in untreated pots and plots, either.

Possible Causes of the Poor Growth

Definite proof of the cause or causes of the trouble has not been obtained. Evidence pertaining to several hypotheses are summarized (4).

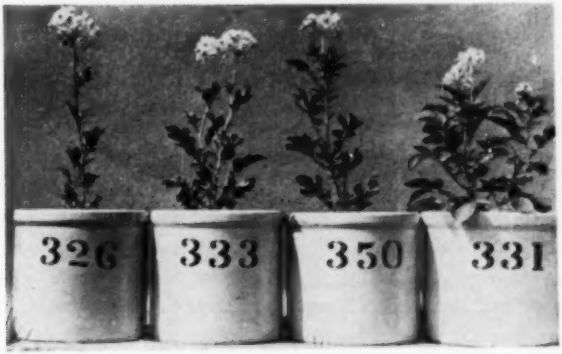

Fig. 1—Potatoes on unproductive soil. All cultures received urea and superphosphate (46 per cent) each at 200 pounds per acre. Other treatments: 326—none; 333—Epsom salts at 200 pounds; 350—Epsom salts and muriate of potash, each at 200 pounds; 331—chalk (precipitated calcium carbonate) at 2 tons.

Physical Condition of the Unproductive Soil

The short, shallow development of plant roots and the tendency of the soil to become sealed with fine particles suggested that poor aeration might be the cause of the poor growth. However, neither mixing the unproductive soil with 50 per cent sand nor pumping air through it improved the growth of potatoes in pots.

The addition of sodium carbonate at 3180 pounds per acre increased the above ground growth of tomatoes eighteen-fold in a pot experiment.

On field plots on the problem soil, adding 2600 pounds of sodium carbonate per acre disked in the day before planting in 1949 was very toxic to potatoes that year but in the second year following application, potatoes grew much larger on these plots than on the untreated soil and the yield was more than doubled. The pH of the soil taken in the row above the fertilizer bands, during the summer of 1950 in the untreated plot, was pH 4.6 while it was 5.6 on the plots treated with 2600 pounds of sodium carbonate. It is well known that sodium carbonate deflocculates the soil particles, resulting in poorer soil structure. The beneficial effect of decreasing the acidity will be discussed later.

Chemical Conditions in the Unproductive Soil

The presence or absence of organic substance which might be toxic to plant growth has not been determined.

The evidence on the inorganic conditions is summarized under two headings: 1. Deficient Plant Nutrients, and (2), Toxic Elements.

Deficient Plant Nutrients

Calcium: A deficiency of calcium as the cause of the trouble was eliminated because large additions of gypsum did not affect the growth of potatoes and also sodium carbonate was beneficial to potatoes (Table 4) and was as beneficial to growth of tomatoes as an equivalent amount of lime.

It should be recalled, however, that Fried and Peech (5) found that several crops did not obtain their calcium requirements for optimum growth from gypsum in acid soils. Conversely, Arnon and Johnson (1) demonstrated that certain other species absorbed appreciable amounts of calcium at pH 4.0 in culture solutions.

Magnesium: There was no indication of magnesium deficiency on the plants and there was no improvement in growth of potatoes from the addition of 200 pounds of Epsom salts per acre (Figure 1).

Phosphorus and Potassium: The available supplies of phosphorus and potassium were "high" in the unproductive soil and markedly improved growth and yield of potatoes resulted from adding only lime (Table 4 and Figure 2). On the other hand, the marked improvement in growth of potatoes on superphosphate treated soil might be considered evidence that phosphorus was deficient (Table 2).

Minor Elements (Boron, Manganese, Zinc, Molybdenum): In a pot experiment, the addition of borax at ten pounds, manganese sulfate at 30 pounds and zinc sulfate at ten pounds per acre rate to some of the unproductive soil which had received lime (chalk at 2700 pounds per acre) did not result in any improvement in growth of potatoes.

Neither the soaking of freshly-cut seed potatoes in either 0.01 or 0.1 per cent sodium molybdate solution for ten minutes just before planting nor adding sodium molybdate at one pound per acre to limed or unlimed plots of the unproductive soil had any appreciable effect on the growth of potatoes.

Complex Organic Substances: Stable manure at 20 tons, peat at 10 tons, and straw or sawdust at 4 to 16 tons per acre had very little beneficial effects on the growth of potatoes on unlimed soil. Finely ground alfalfa or castor pomace at four tons per acre were ineffective alone, but at one ton, in conjunction with chalk at one ton, increased appreciably the growth and yields of potatoes in pots, probably because of the extra nitrogen.

In view of the results, it is concluded that the poor growth of plants on the unproductive soil is not due to a deficiency of a plant nutrient.

Toxic Elements

In the literature pertaining to the poor growth of plants on acid soils are many references to the toxicity of manganese and aluminum. These were considered possible causes of the trouble with the unproductive soil.

Besides manganese and aluminum, it was thought that copper from Bordeaux spray might have accumulated in toxic amounts in the unproductive soil. The experimental evidence on each of these phases of the problem are presented and discussed below.

(1) Copper: The easily soluble copper (9) in the unproductive soil was six or more times that in the soils of adjacent fields with more organic matter where potatoes were growing very well. Either precipitated chalk, pure calcium carbonate, at 2 tons, or superphosphate at 8 tons reduced appreciably the soluble copper in the soil and greatly improved the growth of potatoes (Table 3). Peat alone at 10 tons was ineffective in both respects. A productive soil was treated with copper sulfate at from 100 to 1600 pounds per acre, but potatoes showed injury only at the highest rate and then only to the roots. The acidity of the soil was increased from pH 5.3 to 4.6 and the soluble manganese from a trace to 50 pounds per acre by the 1600 pound application of copper sulphate.

As 1600 pounds per acre of copper sulphate added to these pot cultures was probably about equal to the total applied in Bordeaux to the unproductive soil during the thirteen years of growing potatoes and as both of the very beneficial treatments, chalk and superphosphate, did not depress markedly the amounts of readily soluble copper, it appears doubtful if toxic copper is the cause of the poor growth of crops.

TABLE 1.—*Soluble copper and growth of potatoes in different soils*

Soil[1]	Special Treatment[2] (Tons Acre)	Soluble Copper[3] (p.p.m.)	Organic Matter (Per cent)	Growth of Potatoes
M	None	60		Very poor
"	2 Chalk	40		Good
"	4 Chalk	30	2.7	Good
"	2 Super.	60		Fair
"	8 Super.	40		Good
"	10 Peat	60	———	Very poor
C	None	10	3.6	Very good
H	None	3	6.0	Very good

[1] "M" — the unproductive soil. Soils "C" and "H" were from fields adjacent to "M" and had grown good crops of potatoes for six and thirteen years respectively.
[2] Chalk — pure calcium carbonate; Super. — Superphosphate (20 per cent).
[3] Determinations by A. V. King, Agronomy Section, Plant Science Department, University of Connecticut, Storrs.

(2) Manganese: The toxicity of manganese to tobacco on acid soils in central Connecticut where the unproductive soil is located has been reported by Jacobson and Swanback (8). Brown or black lesions on the stems, shown by Berger and Gerloff (2) to be a symptom of manganese toxicity of potatoes in Wisconsin, have seldom been seen on potatoes growing on

the unproductive soil. On the other hand, this symptom was very prevalent on potatoes on two unlimed, productive soils treated with either 400 or 800 pounds per acre of manganese sulphate. The trouble was accentuated when superphosphate (20 per cent) at 8 tons was also mixed with the soil. This may be due to the fact that some sources of superphosphate contain manganese and also increase acidity slightly. Until late in that experiment, however, the manganese sulphate plus superphosphate caused a larger growth of potato plants than where no manganese sulphate or extra superphosphate was added. To a lesser extent, this was true of the unproductive soil. The yields of tubers on the unproductive soils, were increased appreciably by additions of manganese sulphate alone at several rates, the highest 800 pounds per acre.

In other pot experiments where varying amounts of lime or superphosphate were applied to the unproductive soil, the solubility of the soil manganese was greatly depressed by lime, but relatively small decreases of easily soluble manganese of only short duration were caused by superphosphate alone, even at 16 tons per acre. However, the growth of potatoes was improved greatly by lime and/or large amounts of superphosphate (Table 2).

TABLE 2.—*Soluble manganese and aluminum in soil and yield of potatoes*

Treatment of Unproductive Soil[1] (Tons per Acre)	pH	Pounds per Acre of Soluble[2]		Roots (Grams)	Tubers (Grams)
		Manganese	Aluminum		
None	4.9	75	500	2.7	20
3 Lime + 3 Super.	6.2	trace	50	4.4	48
12 Super.	4.9	75	100	5.4	49

[1] Lime — precipitated chalk; Super. — superphosphate (20 per cent).
[2] In Morgan's Universal Solution (pH 4.8).

Relative to the question of the toxicity of manganese, the data in table 2 are pertinent. These data show that although the acidity and the soluble manganese in the unproductive soil had not been changed by an earlier application of superphosphate at 12 tons per acre, the soluble aluminum had been greatly decreased and the yields of the potatoes more than doubled by that treatment. Those increased yields were about the same as where three tons each of lime (in form of chalk) and superphosphate were applied, but the soil with this treatment had only a trace of soluble manganese and slightly less soluble aluminum than the culture with superphosphate at 12 tons.

TABLE 3.—*Effect of lime and superphosphate on soluble manganese and aluminum in the problem soil and on growth of potatoes — Greenhouse Experiment — Katahdin Variety — 1949*

Treatment[1] Pounds Per Acre	Soil Sampled Six Weeks after Planting			Plant Growth (See Fig. 2)
	pH[2]	Pounds Per Acre[3] of Soluble[3]		
		Manganese	Aluminum	
None	4.7	35	500	Very poor
8000 Super.[4]	4.7	75	500+	Poor
1500 Lime[5]	5.3	35+	500	Good
Lime[5] + 8000 Super.[4]	5.3	50	250—	Very good
Lime[5] + 16000 Super.[4]	5.2	50+	50+	Very good +

[1] All pots received 150 pounds N, 200 pounds P_2O_5, 200 pounds K_2O, and 50 pounds water soluble MgO per acre, plant basis (20000 plants per acre). Fertilizer applied in band 2 inches away from seed.
[2] Average of three pots. Core samples taken in top 4 inches of soil above the fertilizer band.
[3] Morgan Universal Extracting solution.
[4] Superphosphate (20 per cent) mixed with central core of soil 5½ inches diameter 4 inches deep. These rates of application are for the part of the soil with which the superphosphate was mixed.
[5] Lime—1500 pounds hydrated magnesium lime per acre mixed with all soil in pot.

In a pot experiment comparing effects of moderate liming and/or superphosphate but where basic fertilizer treatments were increased, thus resulting in greater acidity, there was no decrease in easily soluble manganese in soil samples taken six weeks after planting (Table 3). There was actually an increase in soluble soil manganese with superphosphate applications on both the unlimed soil and on the soil limed with 1500 pounds of hydrated lime per acre. Very good growth occurred where the unproductive soil was moderately limed and 8000 pounds per acre of 20 per cent superphosphate had been mixed in the top 4 inches of soil; these treatments reduced the soluble aluminum content to less than one-half of that in the untreated soil (Table 3 and Figure 2). Still better growth occurred where 16,000 pounds per acre of 20 per cent superphosphate was mixed with the top 4 inches of soil in addition to being limed. The soluble aluminum had dropped to 50 pounds per acre or only one-tenth that in either the unlimed or unphosphated soils, whereas no reduction in soluble soil manganese occurred.

In the Wisconsin investigations, Berger and Gerloff found manganese toxicity was eliminated by mixing ground limestone at 2000 pounds per acre with the soil. The trouble in the probably sandier, unproductive Connecticut soil was not eliminated by such moderate limings.

Response to lime in field: On field plots on the unproductive soil, potatoes have not grown as well with 1500 pounds per acre of hydrated dolomitic

lime as with 2600, 5200, or 10,400 pounds. In 1950, yields of potatoes increased with increasing amounts of lime from 145 bushels per acre on the no-lime plots of the lime series to 288, 340, 348, and 406 bushels per acre on plots which received respectively, 1500, 2600, 5200, and 10,400 pounds of hydrated dolomitic lime (Table 4). Tests of soil samples taken near the potato roots indicated the presence of only low amounts of soluble manganese with either of the lower rates of liming, and only trace amounts where the two upper rates of lime were applied. The soluble aluminum content in these soil samples, however, decreased with increasing amounts of lime from 500 pounds per acre in the soil which received 1500 pounds lime per acre to 50 pounds in the plot which received the heaviest rate of lime (Table 4).

Fig. 2—Potatoes on unproductive soil with treatments as follows: 5—none; 17—superphosphate at 4 tons; 7—hydrated lime at 1500 pounds; 14—treatments 17 + 7.

The beneficial effect of the heaviest lime treatment resulting in greater improvement in growth and yield of potatoes appears to be due to its effect in further reducing the soluble aluminum content in the soil. From the standpoint of favoring scab, the application of more than about 2000 pounds of hydrated dolomitic lime on this soil would probably be impractical.

Response to superphosphate in field: The application of 20 per cent superphosphate at the rate of one ton per acre in a six-inch band on shallow covered seed on plots which had been moderately limed (1500 pounds per acre), resulted in the production of normal and vigorous potato plants (Figure 4). These plants remained dark green in color until killed by frost and produced the highest yields of all treatments compared on Section IV (Table 4). This treatment was just as effective as heavy liming in reducing the soluble aluminum content of the soil.

TABLE 4.—*Effect of rate of lime and other soil treatments on soluble manganese and aluminum in soil and yield of potatoes — 1950*

Treatment[2] Pounds Per Acre	Soil Sampled above Fertilizer Bands 7/14/50			Yield[1] (Bus./A.)
	pH	Pounds Per Acre Soluble (Morgan)		
		Manganese	Aluminum	
1. No lime	4.6	50	500	145
2. 1500 lime[3]	5.0	10	500	288
3. 2600 lime	5.4	10	100+	340
4. 5200 lime	6.1	trace	100	348
5. 10,400 lime	6.6	trace	50	406
6. 2560 sodium carbonate[3]	5.5	15	200	230
7. 2 + 2000 20 per cent super. over seed[4]	5.1	5	50	422
8. 2 + 4000 46 per cent super.[3]	[5]	—	—	378
9. 2 + 8000 46 per cent super.[3]	[5]	—	—	415

[1] Potatoes had been planted annually since 1935. This area with lime rate treatments called Section IV was not so severely affected by toxic conditions as Sections 2 and 3 (Table 6). Potatoes planted May 31, 1950. Yield is average of three plots, each 6 rows x 36 feet.

[2] All plots received 150 lbs. N, 200 lbs. P_2O_5, 200 lbs. K_2O, and 30 lbs. water soluble MgO per acre in bands at planting time.

[3] The hydrated magnesium lime, or sodium carbonate, or 46 per cent superphosphate applied May, 1949.

[4] Superphosphate (20 per cent) applied in six-inch band above shallow covered (½ inch) seed, and soil ridged above at planting time.

[5] Soil samples not obtained.

The beneficial effect of the broadcast applications of 4000 and 8000 pounds of 46 per cent superphosphate applied in May, 1949 was carried over into the second year in that good growth and yields of potatoes were obtained (Table 4). Better growth and somewhat better yields were obtained, however, on the plots where 2000 pounds of 20 per cent superphosphate had been applied over the shallow covered seed at planting time in both 1949 and 1950.

Response to organic matter in field: The beneficial effect of plowing under more organic matter, in the form of rye and millet, in counteracting the toxic condition of the soil is shown in the comparisons of yields obtained in Sections 2 and 3 in table 5. Since the rye was not planted on Section 2 until the latter part of October, following potato harvests, there was only a very light growth of rye (about 600 pounds top growth each year) for plowing under in the middle of May of 1949 and in 1950. On section 3, however, the 1949 spring growth of rye was not plowed under until nearly mature. After the rye was plowed under, millet was planted, and it was plowed under in September. Rye seeded in September on this section produced about 2000 pounds of above ground dry weight by the time of plowing, May 1950.

TABLE 5.—*Effect of rotation and soil treatments on soluble manganese and aluminum in soil and yield of potatoes — 1950*

Treatment[1] Pounds per Acre	Soil Samples of 7-14-50[2] pH	Pounds per Acre of Soluble Manganese	Pounds per Acre of Soluble Aluminum	Yield[1] (Bus./A.)
Section II — Area in Potatoes Every Year Since 1935				
1. None	4.4	50	500	82
2. 1500 lime[3]	4.8	25	500	212
3. 2 + peat[4]	4.9	5	250	327
4. 2 + 2000 20 per cent super.[5] above seed	5.1	5	50	402
5. 4 + peat	5.1	5	50	479
Section III — Full Y[illegible] of Rye and Millet 1949 — Potatoes 1950				
1. None	4.5	25	500	153
2. 1500 lime[3]	5.2	25	250	325
3. 2 + 2000 20 per cent super. above seed[5]	5.1	10	20	429

[1] All plots received 150 lbs. N, 200 lbs. P_2O_5; 200 lbs. K_2O; and 30 lbs. water soluble MgO in bands at planting time. Potatoes planted May 29, 1950. Yield is average of three plots, each 8 rows x 36 feet.

[2] Morgan Universal extracting [illegible]olution; soil sampled above fertilizer bands July 14, 1950.

[3] Hydrated magnesium lime applied one-half in fall 1948 and one-half in spring 1949.

[4] Peat at 15 cu. yds. per acre applied in row.

[5] 2000 lbs. 20 per cent superphosphate applied in six-inch band above shallowed covered (½ inch) seed and soil ridged above at planting time.

The total top growth of two crops of rye and one crop of millet plowed under on Section 3 was about 8000 pounds dry matter per acre as compared with a total of only 1200 pounds of top growth produced by two winter covers of late seedings of rye plowed under on Section 2 planted to potatoes annually. The unlimed plots and those which received 1500 pounds hydrated lime on Section 2 averaged 82 and 212 bushels per acre respectively, as compared with 153 and 325 bushels per acre on plots which received these treatments on the rotated section (Section 3). Thus, the 1950 yields were increased considerably as a result of not planting potatoes in 1949 and plowing under more organic matter. With lime the use of 2000 pounds of 20 per cent superphosphate applied in a six-inch band above the seed resulted in practically the same yields of approximately 400 bushels per acre on either section.

Analyses of leaves of potato plants grown in pot cultures of problem soil treated with lime, superphosphate and peat show a greater reduction in content of aluminum and iron, than in manganese. These chemical changes coincided with improvement in growth. The addition of lime

only, resulted in a considerable reduction of both manganese and aluminum in the leaf tissue, whereas superphosphate, in addition to lime, did not result in any appreciable reduction of manganese but did result in further reduction of aluminum in the tissue. These data further suggest that manganese is not the principal cause of the toxicity.

In another experiment, steaming for one hour more than doubled the exchangeable manganese in the unproductive soil, yet potato plants increased 50 per cent and the tubers 300 per cent in weight. Dry heat, 95°C., had no effect on the exchangeable manganese, but resulted in an increase in the size of the plants as much as the steaming.

The fact that the roots of potato plants grown in the unproductive soil were greatly reduced in both length and weight is another strong point against manganese being the toxic principle. For instance, Bortner (3) found that tobacco plants in solutions containing 15 parts per million of manganese developed quite normal root systems but showed marked symptoms of manganese toxicity on the leaves.

It appears to the writers that the evidence does not support the hypotheses that manganese toxicity is the *only* direct cause for the poor growth of plants on the unproductive soil.

(3) Aluminum: There are numerous references in the literature to aluminum toxicity to plants growing in acid soils. In 1943, Hutchinson (6) published critical reviews and an extensive bibliography of the research on this element in soils, plants and animals. In 1945, a brief summary of those reviews appeared in Soil Science (7). From 1918 to 1935, Hartwell, Burgess, Pember, McLean, and Gilbert at the Rhode Island Station conducted many experiments on this subject and drew the general conclusions that the aluminum and not the hydrogen ion was the chief, direct cause of poor growth of many species on acid soils. Their soil trouble was counteracted with either lime or large amounts of superphosphate and this is also true of the unproductive Connecticut soil. The difficulty is, of course, to prove that aluminum *is* the direct cause of the poor growth of plants. On the affirmative side may be listed such facts and observations as:

(1) The roots of several species growing in the unproductive soil were greatly shortened and thickened and had few branches, a symptom associated with aluminum toxicity by other investigators.

(2) The addition of superphosphate reduced greatly the soluble aluminum in the unproductive soil and improved markedly the growth of potatoes (Tables 3, 4 and 5). The soluble manganese was also reduced temporarily by superphosphate but potatoes grew well *after* the soluble manganese had increased to its original level (Table 2).

(3) When aluminum sulphate was applied at 8 tons per acre (1280 pounds aluminum) to the unproductive and two productive soils, the

growth of potatoes in pots was greatly reduced in all cases and the margins of the leaves turned yellow, symptoms very similar to those exhibited by potatoes on the unproductive soil fertilized with an acidifying carrier of nitrogen. Only one stem lesion, a symptom of manganese toxicity, occurred on six potato plants on the soil treated with aluminum sulphate.

(4) According to Pierre *et. al.* (10), organic matter in soils reduces the aluminum in displaced soil solutions. In the present experiments, replacing one-quarter of the unproductive soil with untilled, unfertilized pasture soil, just as acid and high in soluble aluminum and manganese as the unproductive soil, but having more than twice as much organic matter, resulted in a nearly normal growth of potatoes. Finely divided peat at 15 cu. yds. per acre in the row or at 90 cu. yds. mixed with all the soil, in addition to relatively small amounts of lime, or lime and superphosphate, has improved the growth of potatoes above lime or superphosphate alone on plots of the unproductive soil. The addition of peat resulted in a reduction of soluble aluminum in the problem soil (Table 5). Rotating potatoes with rye or millet has been beneficial to subsequent crops of potatoes on fields

Figure 3—Effect of lime, superphosphate, and peat on Katahdin potatoes grown on unproductive soil. Both plots received 2500 lbs. 6-8-8 with 1¼ per cent water soluble magnesia per acre in bands at planting time. Photographed August 7, 1950.
Plots on left foreground: No lime. Average yield on no lime plots on this area (Section 2), 82 bushels per acre.
Plot on right foreground: 1500 pounds hydrated magnesium lime broadcast plus 2000 lbs. 20 per cent superphosphate in six-inch band over shallow covered seed and 15 cu. yds. peat in row at planting time (per acre rate). Average yield was 479 bushels per acre. See table 5 for yields with lime only ,or with lime and superphosphate only.

of the farm with the unproductive soil. The effect of the rotation in reduction of soluble aluminum in the soil is shown in table 5. In a study of sixteen potato soils, relatively high levels of organic matter appeared to be associated with vigorous potatoes.

Summary and Conclusions

In the thirteenth consecutive year of growing potatoes, with little or no rye cover, a formerly productive soil was found to be very unproductive though liberally fertilized with a complete fertilizer containing sufficient water soluble magnesium. The fine sandy loam was strongly acid, pH 5.0 (in early spring), containing about 2.7 per cent organic matter, and had the following amounts of easily soluble elements: very high in soluble aluminum and manganese; high, in phosphorus and potassium; but low, in magnesium and iron, and very low in calcium.

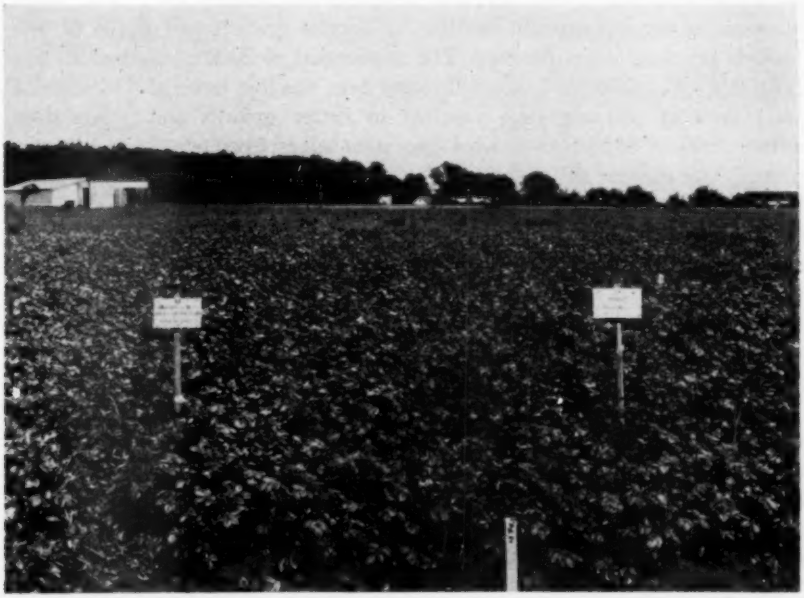

Figure 4—Good growth of Katahdin potatoes on unproductive soil in response to treatments. Photographed August 7, 1950.
Both plots received 2500 lbs. 6-8-8 with 1¼ per cent water soluble magnesia per acre in bands at planting time.
Plot on left foreground: 1500 lbs. hydrated magnesium lime per acre rate broadcast May 1949, plus 2000 lbs. 20 per cent superphosphate in six-inch band over shallow covered seed at planting time. Average yield of plots so treated on this area (Section 4), 422 bushels per acre.
Plot on right foreground: 10,400 lbs. hydrated magnesium lime per acre rate broadcast May 1949. Average yield of these plots was 406 bushels per acre. The no-lime plots on this section averaged 145 bushels per acre.

Potato plants were very small and spindly, and the roots were short and stubby. Other crops including millet, rye, and tomatoes also had very small root development on the untreated soil.

Any treatments that reduced the acidity of the soil, including sodium carbonate, were beneficial and, conversely, those that increased the acidity, accentuated the trouble.

Moderate lime applications relieved the situation, but heavy liming, 5000 to 10,000 pounds of hydrated magnesium lime per acre, was necessary to obtain normal growth. In 1950, yields increased from 145 bushels per acre on the no lime plot to 406 with the heaviest rate. The heaviest lime applications, however, resulted in a chlorotic condition of the leaves during the latter part of the growing season, possibly caused by manganese *deficiency*. Such heavy lime applications are, of course, impractical with respect to favoring scab.

Moderate liming (1500 pounds hydrated magnesium lime) plus large amounts of superphosphate resulted in normal growth and yields of 400 bushels per acre were obtained. The application of 2000 pounds of 20 per cent superphosphate in a six-inch band over shallow covered (½ inch of soil) seed at planting time resulted in better growth and yields than where 4000 or 8000 pounds of *46 per cent* superphosphate (equivalent in phosphorus content to 9200 and 18,400 pounds of 20 per cent) had been broadcast the previous year.

Adding more organic matter to the soil by growing rye and millet during one year resulted in improved growth and a considerable increase in yield (Table 5).

The toxic effects of copper, manganese and aluminum were considered as direct causes of the trouble. Of these, the evidence appears strongest for aluminum but definite conclusions have not been reached.

Heavy lime applications markedly reduced soluble manganese and aluminum in the soil. Heavy superphosphate applications plus moderate liming reduced the aluminum content of the soil markedly, but with much less decrease in soluble manganese. The addition of organic matter in the form of green manure crops or peat also reduced the soluble aluminum in the soil.

Practical Methods for Overcoming This Kind of Soil Toxicity

This type of soil toxicity has been reduced by three different methods: (1) application of lime, (2) applying large amounts of superphosphate, and (3) adding organic matter.

The amount of lime to apply should not be high enough to favor scab. When the reaction of the soil is higher than about pH 5.3, scab usually becomes serious in a short rotation and especially if potatoes are planted annually.

Until the toxic condition can be reduced to a minimum through moderate liming and plowing under considerable amounts of organic matter, the use of superphosphate, applied in a six-inch band on top of shallow covered seed pieces at planting time can be used as an emergency treatment. This emergency treatment was employed successfully by a grower who top-dressed only the shallow-covered row with superphosphate and then covered the superphosphate and seed pieces with more soil, using cultivator shovels.

Literature Cited

1. Arnon, D. I., and Johnson, C. M. 1942. Influence of hydrogen ion concentration on the growth of higher plants under controlled conditions. Plant Phys. 17: 525-539.
2. Berger, K. C., and Gerloff, G. C. 1947. Manganese toxicity of potatoes in relation to strong soil acidity. Soil Sci. Soc. Amer. Proc. 12: 310-314.
3. Bortner, C. E. 1935. Toxicity of manganese to Turkish tobacco in acid Kentucky soils. Soil Sci. 39: 15-33.
4. Brown, B. A., Hawkins, A., Rubins, E. J., King, A. V., and Munsell, R. I. 1950. Causes of very poor growth of crops on a formerly productive soil. Soil Sci. Soc. Amer. Proc. 15: (In press).
5. Fried, Maurice, and Peech, Michael. 1946. The comparative effects of lime and gypsum upon plants grown on acid soils. Jour. Amer. Soc. Agron. 38: 614-623.
6. Hutchinson, G. Evelyn. 1943. The biochemistry of aluminum and certain related elements. Quar. Rev. Biol. 18: 1-29, 128-153, 242-262, 331-363.
7. ———. 1945. Aluminum in soils, plants, and animals. Soil Sci. 60: 29-40.
8. Jacobson, H. G. M., and Swanback, T. R. 1932. Manganese content of certain Connecticut soils and its relation to the growth of tobacco. Jour. Amer. Soc. Agron. 24: 237-245.
9. King, A. V. 1947. A method for the determination of soluble copper in soils. Jour. Amer. Soc. Agron. 39: 610-614.
10. Pierre, W. H., Pohlman, G. G., and McIlvaine, T. G. 1932. Soluble aluminum studies. I. The concentration of aluminum in the displaced soil solution of naturally acid soils. Soil Sci. 34: 145-160.

Solanum Xanti Gray and *Solanum integrifolium* Poir., NEW HOSTS OF THE GOLDEN NEMATODE, *Heterodera rostochiensis* Wollenweber.

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A reliable method for testing the susceptibility of plants to the golden nematode is needed for use in the research program on the control of this pest. In one part of this program an attempt is being made to find all possible hosts of this organism among commercial crops, ornamentals, and weeds. For this purpose it must be possible to detect the presence of small numbers of nematodes on the roots because several species have been found to be lightly infected. It is the purpose of this paper to describe such a method and to report two new hosts of this nematode.

The procedure that has been adopted for use in our tests is to count the number of immature females on the roots around the periphery of a soil ball removed from a flower pot. Triffitt (2) first used the method of counting the immature nematodes on roots for estimating the extent of infection. The swollen, pearly-white females, which have just emerged from the roots, are relatively easy to locate and recognize.

Young seedlings are transplanted to soil heavily infested with nematode cysts. Five times at weekly intervals the soil ball is removed carefully from each four-inch pot and the roots around the periphery of the soil ball examined for the presence of immature females of the golden nematode. Five readings are used because females tend to emerge later from the roots of resistant plants than from those of susceptible plants. Nematodes emerge first from the roots of *Solanum tuberosum* L., the most strongly attacked species. Therefore, the first reading is made on the test plants when females first emerge from the roots of potato plants transplanted to infested soil at the same time as the test plants. In a test in which the relative effectiveness of different numbers of readings in detecting small numbers of nematodes on the roots was determined, five readings appeared to be the minimum number for maximum efficacy.

If no nematodes are found from the five readings all soil should be washed from around the roots and the entire root system examined for the presence of golden nematodes. If it is desirable to save the root system this last step may be omitted. At least ten plants are examined in this manner.

Solanum Xanti and scarlet or tomato eggplant *(S. integrifolium)* were found to be hosts of the golden nematode. An average of 46 immature females per root system was found for *S. Xanti* and an average of 13 for *S.*

integrifolium. In the same test 713 were found on potato roots, 41 on tomato roots *(Lycopersicum esculentum* Mill*)*, and 22 on European bittersweet *(S. Dulcamara* L.*)* roots, other hosts of this nematode. Only the highest reading of the five readings made on the periphery of each soil ball of each plant was used in computing these averages. The number of nematodes on the roots of either of the two hosts did not approach the number found on potato roots. However, either of these plants growing in infested soil would serve to keep the nematode alive in the absence of potatoes or tomatoes. S. *Xanti* is native to California and *S. integrifolium* is grown in various parts of the United States as an ornamental.

Another method which has been used extensively for testing for susceptibility to the golden nematode and other nematodes is to count the number of larvae inside roots which are growing in infested soil. However, detecting and counting golden nematode larvae inside roots is difficult and time-consuming. Unless sterile soil is used there is the added difficulty of differentiating between golden nematode larvae and larvae of other nematodes.

A third widely-used method for testing resistance to cyst-forming nematodes is to grow plants in infested soil, remove them from the soil at various time intervals, and examine the roots for the presence of immature females. Instead of examining the roots for the presence of immature females it is possible to place them in formalin and determine the number of nematodes on the roots at a later date in the laboratory (1). However, there are two distinct disadvantages to these procedures. First, it is difficult to detect small numbers of nematodes on roots because a high percentage of the immature females are dislodged in removing the roots from the soil. Second, it is necessary to destroy a plant in order to make a reading.

The principal disadvantage of the method used in obtaining the results presented in this paper is that the number of nematodes found on the periphery of the soil ball is influenced by the size of the root system. In recognition of this fact only results from plants in which the roots cover the outside of the soil ball are included. Small pots are used to decrease the time required for roots to reach the outside of the soil ball. An advantage of this procedure is that a reading can be made without destroying the plant. As a result it is possible to test hybrid plants which cannot be replaced. In comparative tests this method has shown greater efficacy in the detection of light infections than either of the other methods mentioned in this paper.

Literature Cited

1. Chitwood, B. G. and Feldmesser, J. 1948. Golden nematode population studies. Proc. Helminth. Soc. of Wash. 15: 43-55.
2. Triffitt, M. J. 1930. Observations on the life cycle of *Heterodera schachtii*. Helminth. Jour. 8: 185-196.

ASSOCIATION OF SPECIFIC GRAVITY WITH WEIGHT OF INDIVIDUAL TUBERS IN LATE CROP POTATOES

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With the mounting interest being shown in specific gravity as a measure for various aspects of quality in potatoes it becomes increasingly important to know whether there is any relation between size as determined by weight and specific gravity of potatoes as normally received on the market.

Caldwell *et al* (1) found very consistent differences in specific gravity between large and small potatoes in early crop immature southern-grown potatoes. The larger tubers always had the higher specific gravity. Le Clerg (4), using two varieties from two locations in Louisiana and Tennessee, found no significant relation between specific gravity and weight of tubers.

In Ireland, Drew and Deasy (3) investigated the relation between size of tubers and the percentage of starch as calculated from specific gravity determinations on several varieties. In general, they found that the larger tubers contained higher percentages of starch, which decreased with decreasing size of the tubers. However, in one variety the smaller tubers were found to contain higher percentages of starch, but Drew and Deasy considered those potatoes abnormal because of a high degree of virus infection.

In the present study five varieties of potatoes from each of three locations were used. One variety (Triumph) was used from two different locations. All the potatoes were of U. S. No. 1 grade and the individual tubers ranged in weight from 59 to 500 grams. Each tuber was weighed and the specific gravity determined by immersion in salt solutions of different concentrations as described by Clark *et al* (2).

RESULTS

In table 1 are given the correlation coefficients for comparison of specific gravity with weight of the individual tubers. As shown by the asterisks, which denote values meeting the five and one per cent levels of significance, only four of the 17 lots gave coefficients that were

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[3] Report of a study made under the Research and Marketing Act of 1946 #147.

significant. Two of these were negative and significant at the one per cent level. In other words the larger tubers in these lots tended to have a lower specific gravity than the smaller tubers. Two lots showed the opposite relation, with the larger potatoes having a higher specific gravity than the smaller ones, but the coefficients were significant only at the five per cent level. These four lots represented four different varieties from widely scattered areas, Green Mountain from Maine, Chippewa from Michigan, Irish Cobbler from North Dakota, and Russet Burbank from Washington. It is of interest to note that the Chippewa, Katahdin, and Irish Cobbler tubers that came from the same farm in Maine as the Green Mountain Maine I lot did not show any significant relation between specific gravity and weight. The tubers in this Green Mountain lot were somewhat larger than the other Green Mountain potatoes, but those in the Michigan Chippewa lot averaged smaller than the other Chippewa potatoes. The two lots having significant positive correlation coefficients did not differ consistently in average weight from the other lots of the same variety. The average specific gravity of each of the four lots showing a significant relation between weight and specific gravity was intermediate in every case between the specific gravities of the other lots of the same variety. Therefore, we have no consistent factors in these data from one crop year that appear to be related to the correlation found between specific gravity and weight.

TABLE 1.—*Correlation coefficients for comparison of specific gravity with weight of potatoes.*

Variety	Location	Tubers	r	Average Specific Gravity	Average Wt.	Range in Weight
		Numbers			Grams	Grams
Green Mountain	Long Island, N. Y.	90	.037	1.092	168	81-364
	Maine I	87	—.420**	1.091	208	118-402
	Maine II	86	.081	1.082	190	98-286
Chippewa	Maine I	89	.027	1.080	199	116-312
	Indiana	80	—.135	1.066	205	91-384
	Michigan	88	—.298**	1.079	134	77-319
Katahdin	Maine I	88	.012	1.087	222	114-325
	Pennsylvania	63	.024	1.076	262	133-392
	Colorado	92	.023	1.091	142	68-297
Irish Cobbler	Maine I	90	.125	1.084	130	82-255
	Wisconsin	80	—.049	1.080	184	80-405
	North Dakota I	89	.232*	1.083	130	59-254
Triumph	North Dakota I	89	—.157	1.081	145	63-329
	North Dakota II	88	.085	1.093	192	81-350
Russet Burbank	Idaho irrigated	87	—.062	1.086	287	122-508
	Idaho non-irrigated	83	—.060	1.097	185	103-370
	Washington	79	.268*	1.091	205	71-500
All lots			—.078*			

* Significant at the 5 per cent level.
** Significant at the 1 per cent level.

A correlation coefficient of —.078 was obtained for all varieties from all locations. This value was significant at the five per cent level but is so low that it has no practical significance. This coefficient means that less than one per cent of the variation in specific gravity is explained by variation in weight.

In considering the practical importance of the relation found in the Green Mountain lot for which a significant correlation coefficient of —0.42 was obtained, we find that only 17.6 per cent of the variation in specific gravity can be explained by the variation in weight. This value is certainly too low to have any practical significance although statistically it was shown that a definite relation between weight and specific gravity existed. In other words if all lots had shown as high a correlation as the Green Mountain lot, it would still be very doubtful whether the relation would be of any practical value for using size to obtain potatoes of different specific gravities.

Summary

Individual weights and specific gravity values were determined on more than 1,400 tubers representing six varieties and 17 lots of potatoes.

Four lots of the 17 gave statistically significant correlation coefficients for weight and specific gravity. Two of the coefficients were positive and two were negative.

No explanation of the relation can be given on the basis of location, size of tubers, or average specific gravity of the lot.

No practical significance as far as separating potatoes for specific gravity on the basis of weight can be given to any of the relations found.

Literature Cited

1. Caldwell, J. S., Lombard, P. M. and Culpepper, C. W. 1943. Variety and place of production as factors in determining suitability for dehydration in white potatoes. The Canner 97 :Nos. 3, 4, 5.
2. Clark, C. F., Lombard, P. M., and Whiteman, E. F. 1940. Cooking quality of the potato as measured by specific gravity. Amer. Potato Jour. 14: 235-242.
3. Drew, J. P., and Deasy, D. 1941. Potato growing in Ireland with particular reference to production for industrial purposes. Jour. Eire Dept. Agr. 38: 220-238.
4. Le Clerg, E. L. 1947. Association of specific gravity with dry-matter content and weight of Irish potato tubers. Amer. Potato Jour. 24: 6-9.

MR. POTATO — PARTNER IN THE LIVESTOCK BUSINESS

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Potato growers and feeders are scanning the profit side of their ledgers with pleasant surprise these days. Experiments in modern feeding methods during the past two years have definitely raised the value of low grade spuds.

Texas dairyman fed 120 cows for 180 days on a ration containing potato hay silage and figured a gain of $3,700 resulting from a 20 per cent increase in milk production. Another dairyman with 100 cows saved $1,500 worth of hay in 100 days and received 50 gallons more milk daily.

Feed values of potatoes from 39.3 cents to 55.8 cents per hundred were recorded in a recent steer feeding experiment at the University of Minnesota. Profits over feed costs in this test ranged from $27.13 to $41.81 per head for steers receiving potatoes in the ration as compared with $16.17 per head for steers on ordinary grain and hay mixture.

In tests with beef at Idaho University, each ton of fresh spuds used replaced 906 pounds of alfalfa and 186 pounds of barley. Gains were increased 20.3 per cent by adding the potatoes to the ration. For lambs, fed at the rate of one to two pounds each daily, one ton of fresh potatoes replaced 562 pounds of alfalfa and 240 pounds of barley.

The best method for figuring competitive feed values and cost of spuds is on the fresh basis, by weight. The Idaho College of Agriculture Experiment Station finds that fresh potatoes, pound for pound, are worth twice as much as wet beet pulp, equal to good corn silage, one-third as good as alfalfa, and one-fourth the value of shelled corn. In feeding tests with hogs, 100 pounds of cooked potatoes replaced 29 pounds of mixed grain, fed two to four with the grain. For fattening lambs, 100 pounds of fresh potatoes equals 28 pounds of alfalfa and 12 pounds of barley.

The 80 per cent water content of potatoes creates shipping, storage and handling problems. Dehydration of potatoes mechanically is still too costly for feeding purposes, but this doesn't worry J. G. Kenney of Park River, North Dakota.

> "I fed 20,000 bushels of cull potatoes last winter (1948-49) using open air freezing as a dehydration agent," said Mr. Kenney. "I merely spread them out on the pasture in the fall and early winter. The cattle dug them out of the snow and in the spring there wasn't a trace of the potatoes, except that the grass was taller and greener where the spuds have lain."

Freezing ruptures the cell walls and the mineral-rich juice drains into the ground as they thaw out. (The potatoes then harden into small lumps of concentrate which keeps indefinitely out-of-doors.)

One North Dakota farmer found that his barley yield was doubled where he spread potatoes in this manner for his hogs. He noted, however, that hogs over 100 pounds do better than small pigs on the frozen spuds.

Sun-power, however, is our most universal dehydration agent. Sun-drying of potatoes can be accomplished to good advantage nearly any place in the United States when the temperature stays above 60 degrees, says J. W. Cannaway of the U. S. Department of Agriculture.

Sun-drying changes the starch grains like cooking the potato, according to laboratory tests. Gains on dehydrated spuds when fed to hogs were slightly higher than on ground corn.

The hogs may feed on the spuds in the drying lots, thus bringing about a great saving in time and labor. Some grain must be fed, however. Ear corn is sometimes thrown on top of the dried spuds.

Cooked potatoes have proved nearly twice as effective as raw spuds for feeding swine. (Tests have proved that nothing is gained by feeding cooked spuds to other stock, however.)

Most farmers, it seems, still feed potatoes fresh or as silage to cattle and sheep, and cook them for their hogs. They should be fed with other food stuff to make a well-balanced ration.

Potatoes should be stored fresh where possible. In this form they have slightly higher feeding value than processed spuds on a dry weight basis. Fresh potatoes should be introduced into the ration gradually. If scouring occurs, the volume of potatoes fed should be reduced, then gradually built up again to the desired maximum feeding. Steers should be started at approximately three to four pounds of potatoes daily, increasing gradually to 20 pounds. If corn silage and potatoes are fed, the two feeds combined should not exceed three pounds for 100 pounds of body weight of the animal daily.

Cooking potatoes for hogs may sound like an endless chore, but North Dakota farmers got around this difficulty by cooking large amounts at a time in salvaged steam engine boilers. The Colorado A and M College Experiment Station cooked spuds for trench silos in ordinary dump truck beds. Grids of perforated water pipe were laid on the truck floors and the pipes were hooked into the steam line of the college power plant. The trucks, loaded with potatoes, were then covered with canvas and steam was forced through the load for 35 minutes. The cooked potatoes did not mush up in the silo, so that a straight wall was maintained at the feeding end. No preservative was added; however, the cooked spuds kept nicely. This feed should replace not more than half of the grain in the ration.

Potato silage for cattle and sheep is most successfully prepared by mixing the raw spuds in the cutter with corn fodder, sorghum, or legumes. The mixture should then be fed at the same rate as straight corn silage. About 600 or 700 pounds of hay to each ton of potatoes are required to take up the excess moisture. Too much over-dry roughage, however, will interfere with proper packing of the silage and cause it to mold.

Extra weight becomes a problem when potato silage is stored above ground. Erect silos should be braced and filled only about two-thirds full. Proper drainage is always necessary but when trench or pit silos are used it becomes an even more important factor. Temporary silos made of snow fence lined with sisal kraft paper, or just walls of bailed hay well packed and bound together have proved successful for storing potato silage. Write to the State Experiment Station at Fort Collins, Colorado, or consult U. S. Department of Agriculture Misc. Bulletin No. 676 in your county agent's office for tips on storing and feeding your culls.

Yes, your partner the potato can help balance your budget in more ways than one. It's wasteful to dump culls and a bad policy to spoil markets with low grades. The demand for table spuds remains about the same regardless of price. No matter which method you use, there is profit in feeding potatoes.

Literature Cited

1. Allender, C. R. 1948. A Texas dairyman. U. S. Dept. of Agr., Misc. Publication No. 676.
2. Beeson, W. M., C. W. Hickman, and D. H. Fourt. 1940. Feeding potatoes to livestock. Coll. of Agr., Univ. of Idaho, Ext. Bull. 134.
3. Connell, W. E.; Tom, R. C., and S. S. Wheeler. 1947. Feeding potatoes to livestock. Colo. Agr. Exp. Sta., Colo. Farm Bull. 37. Vol. 7, No. 2 (June, 1940).
4. Esplin, A. Lamar, and W. E. Connell. 1946. Dehydrated potatoes and alfalfa silage for lambs. Colo. Agr. Exp. Sta., Colo. Farm Bull., Vol. 8, No. 2 (Mar. & Apr. 1946)
5. Fausch, H. D.; Kiser, O. M., and Peters, W. H. Feeding potatoes to beef cattle. Red River Valley Growers Association, Division of Animal Husbandry, University Farm, St. Paul, Minnesota.
6. Malone, C. M. The potato famine in Ireland in the 1840's. (1845-1846). Bayfield, Colo.
7. Mc Calmont, J. R. 1939. Soil types and constructions. Bureau of Plant Indus. and Agr. Eng., U. S. Dept. of Agr. Farmers' Bull., 1820.
8. Strong, Horace T. 1944. Feeding potatoes to livestock. Agr. Exp. Sta. and Kern County, Cal.

LELAH STARKS 1882-1951

MISS LELAH STARKS
A PIONEER SEED POTATO GROWER

G. H. RIEMAN AND H. M. DARLING

University of Wisconsin, Madison, Wis.

Miss Lelah Starks was born in Plainfield, Wisconsin, March 30, 1882. She died in Rhinelander, Wisconsin, January 10, 1951.

Her girlhood was spent with her farm family in Central Wisconsin where she learned the ways of pioneer potato farming. Her education was far more than a formal one; the varied experiences she had with her father as she observed his operations clearing land, testing new varieties, coping with plant pests, and exploring for new potato production areas in the stump land to the north kindled her enthusiasm for the outdoors and instilled in her a spirit of adventure.

The Starks family lived in Chicago for a time while her father, Leonard Starks, developed an extensive potato business. During this period she studied music and travelled to points of interest in the East and in Europe. She also became interested in the breeding and showing of peonies and poultry.

The fundamental changes in the handling and marketing of potatoes which occurred during the early twenties affected the large Starks potato business adversely. Her father died in 1927. The following year Lelah Starks started farming on a section of partially cleared land, near the village of Starks in Northern Wisconsin. The facilities and financial resources at her command were very modest. The depression years soon arrived and potato farming became a rugged enterprise in the cut-over lands of the Lake States. During this difficult period in her life the traditional qualities of the American pioneer—boundless determination, unfaltering courage, and the ability and will to create opportunities—were exemplified in the personality of Miss Starks.

Slowly but surely, amid primitive surroundings, she built her seed growing establishment, dealing with the needs of the present but living with her thoughts on the possible accomplishments of to-morrow. Her objective was the production of dependable high-yielding strains of disease-free seed potatoes for her many friends in the potato industry. To accomplish this purpose the long work days of the growing season passed all too quickly. But there was always progress. Cultivated fields were increased from a few hundred acres to 2500 acres. Of these over 800 acres were cleared—first with horses and hand labor and later with heavy bulldozers. Certified seed potato plantings gradually increased to 700 acres including 60 to 80 acres of well isolated tuber-unit foundation

seed plots. Varieties and strains in commercial production were increased from two to twenty-two. In addition, some 75 new and old named varieties were maintained for research purposes. Warehouse facilities to accommodate a quarter million bushels of potatoes were developed from a modest beginning with rented seed storage space. The old gave way to the new as a full line of modern farming machinery came into operation. Her well equipped machine shop fashioned many improvements which are now in general use. All of these things, important as they are, were but the means to one goal—the production of excellent strains of seed potatoes.

Miss Starks can, in a very real sense, be considered one of the outstanding pioneer potato farmers of our nation. She was personally largely responsible for the development of many superior clonal strains of disease-free seed potatoes which are now grown on thousands of acres throughout the country. Her fields were her laboratory; her warehouses were her office, and to them came growers and agricultural scientists to study her methods and to consult with her on practical and technical phases of potato seed production. In 1941, the University of Wisconsin granted honorary recognition of "Lelah Starks who has given courageous and needed leadership to the application of science to potato growing." She was a member of the Potato Association of America and attended the recent annual meeting at Memphis, Tennessee.

But with all her success, Miss Starks remained a remarkably modest and unassuming person, a woman with a kindly interest in the personal welfare of her workmen and their families. She was glad to give of her knowledge and her experience to a grower friend or to an earnest young graduate student from the University. Prompted by her deep faith in scientific rather than empirical farming methods, she gave generously of her time and resources to the support of agricultural research.

Miss Starks had the "green touch" in growing crops. None of those who knew her will forget her enthusiasm and respect for the things she loved most—acre after acre of expertly cared for potatoes and the land upon which they grew.

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When you buy Niagara brand dusts you can be sure of the best protection, for their effectiveness has been pre-proved in the field and their quality has been laboratory-guarded through every step of manufacture. When in doubt as to the proper protection for your crops "ask the Niagara man". He is a trained insect and disease control specialist living in your neighborhood, ready to serve. Write us and he will see you.

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†Trade Mark *Reg. U.S. Pat. Office

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Widely used in potato growing areas from coast-to-coast, these General Chemical spray materials have a reputation for standout field performance against "bugs" and blights.

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FOR DEPENDABLE CONTROL OF ALL BLIGHT

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